

NRA
TIM #1



Capacity Improvements Through Automated Surface Traffic Control

Brian Capozzi, Ph.D.

Presented at NASA Ames Research Center

Moffett Field, CA

May 21-23, 2002

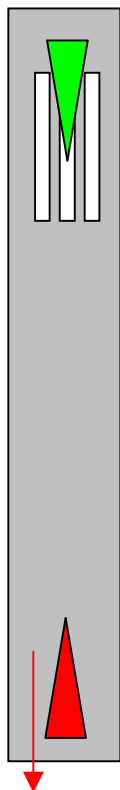


Agenda:

- **Need for Automation of Surface Control**
- **Meet the Metron Aviation Team**
- **Concept Overview and Core Ideas**
- **Enabling Technologies**
- **Roadmaps for New Technologies**
- **Metrics of Goodness and Costs/Benefits**
- **Summary and Motivation for Getting There**

The Need for Surface Automation...

Surface Constrains NAS Throughput

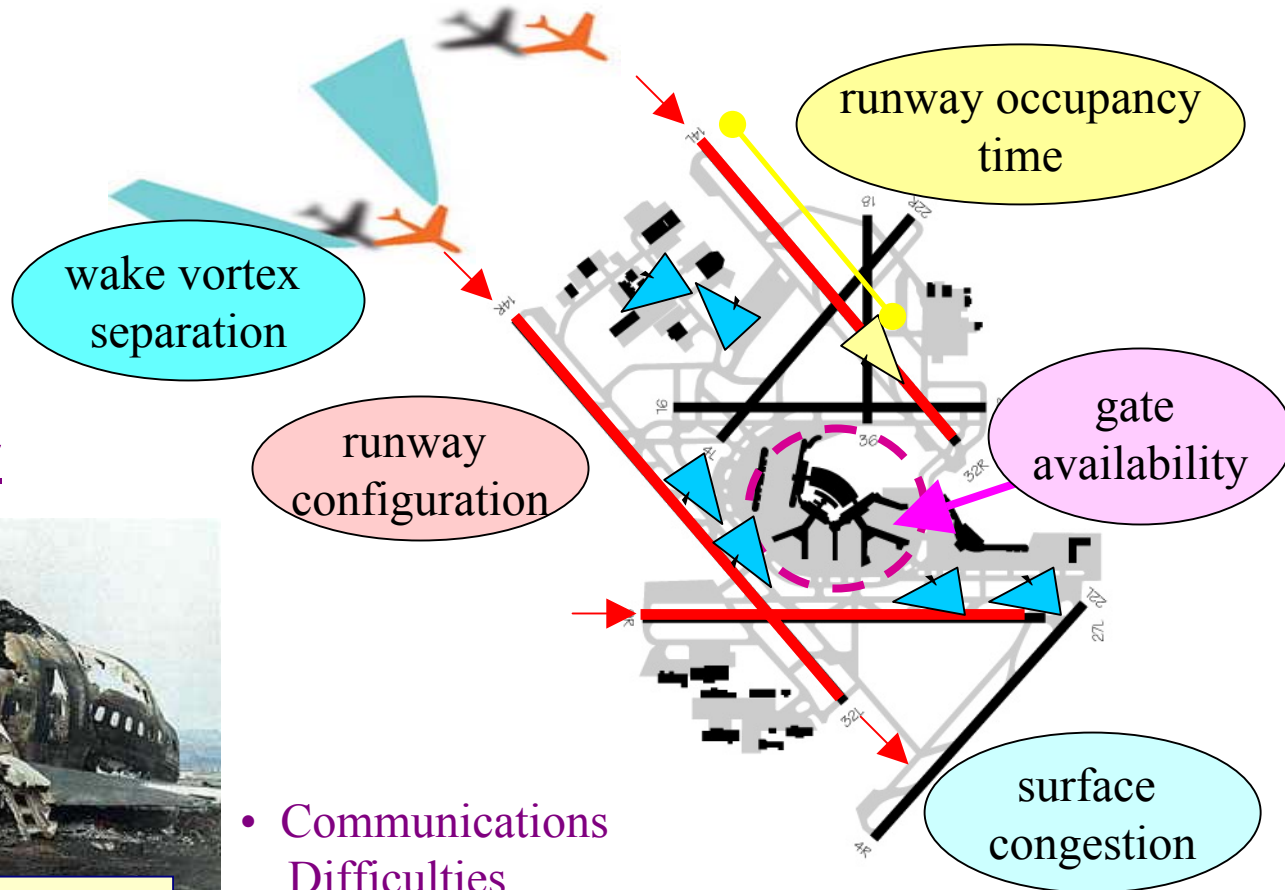


Surface Safety



1977 Tenerife...

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- Communications Difficulties
- Visibility Problems
- Situation Awareness

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Metron Aviation Team of Topical Experts



*Principal
Investigator*

Brian Capozzi, Ph.D.

Metron Aviation

Path Optimization

Autonomous Systems

Algorithm Design



Chris Brinton

Metron Aviation

Surface Automation

Decision Support Tools

Software Development



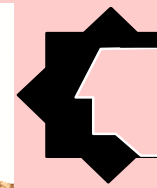
Bruce Ware

Metron Aviation

Ops Expertise

Statistical Analysis

ATSP Experience



Prof. Phil Smith

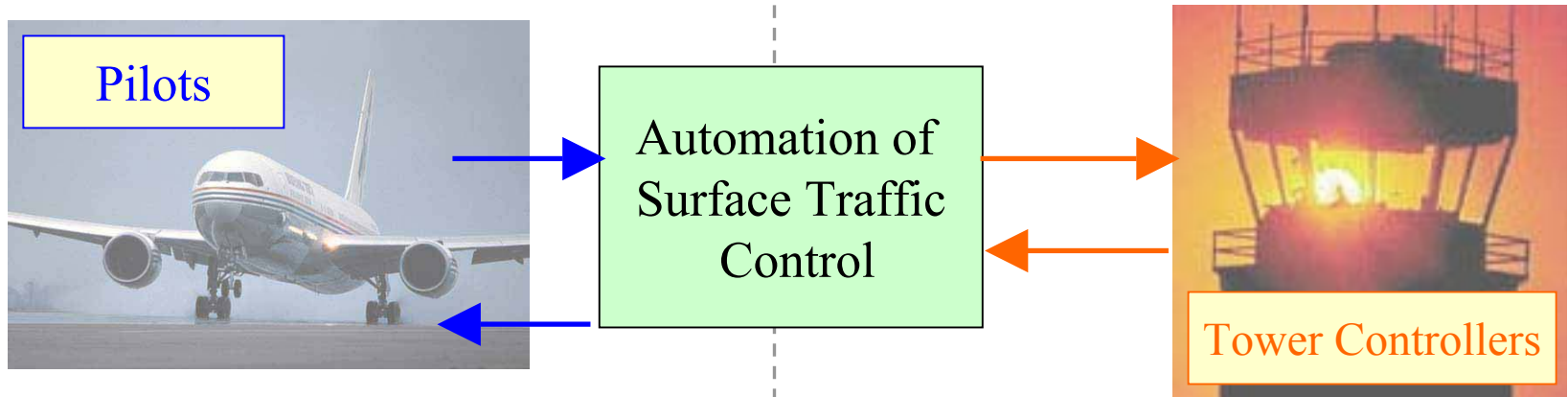
Cognitive Systems

Human Factors

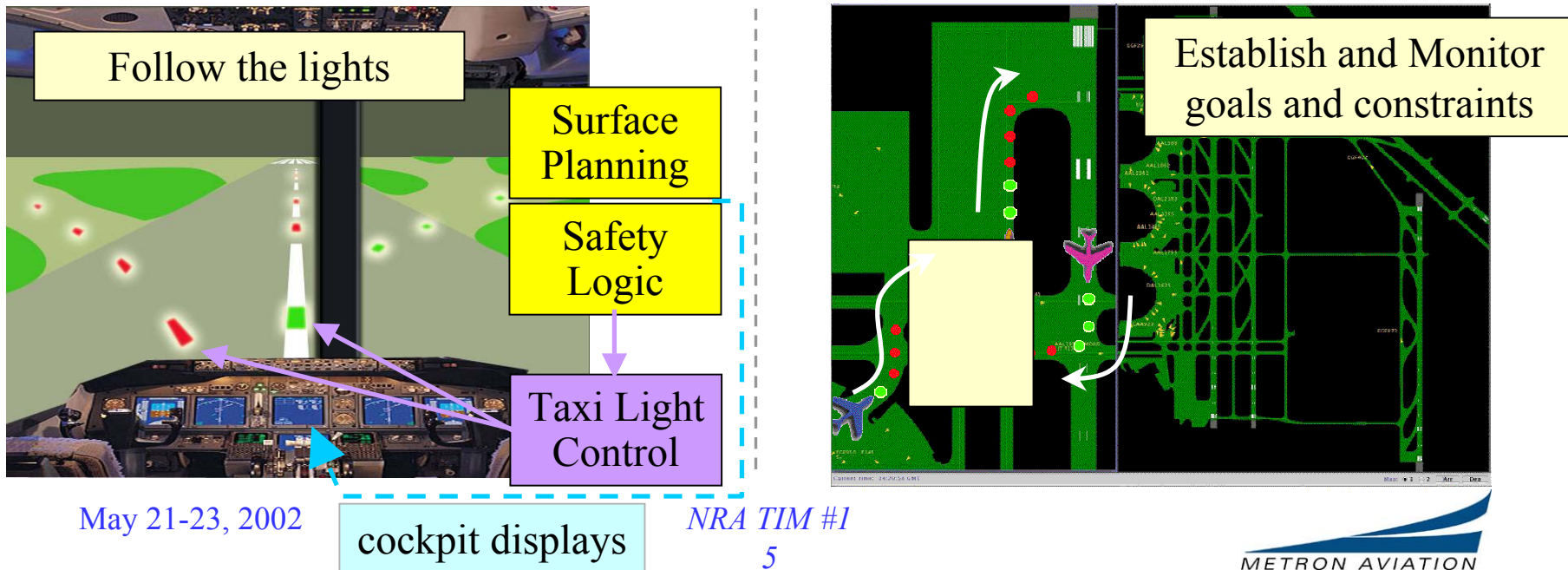
Roles, Responsibilities, &

Procedures

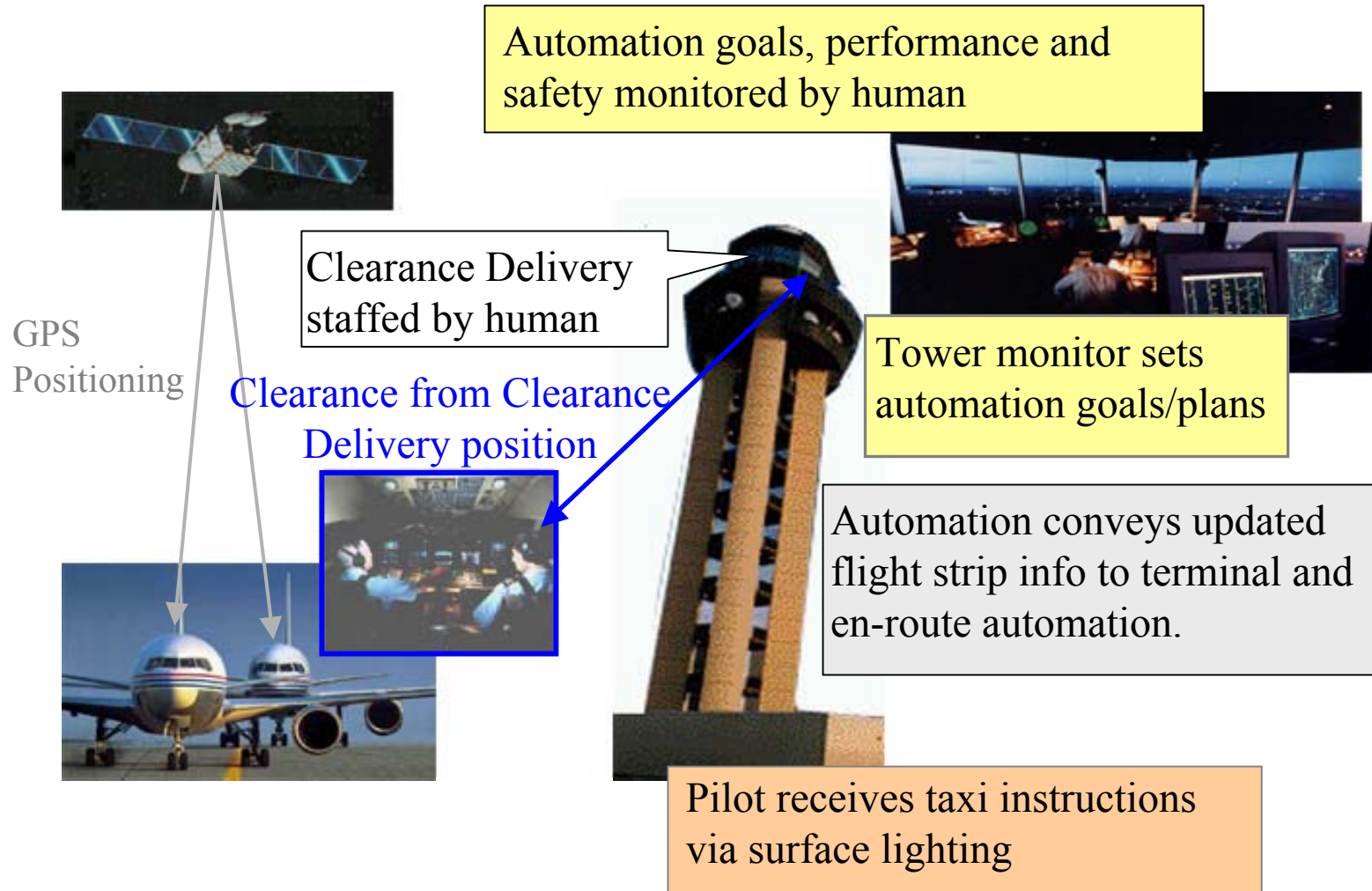
Concept Overview



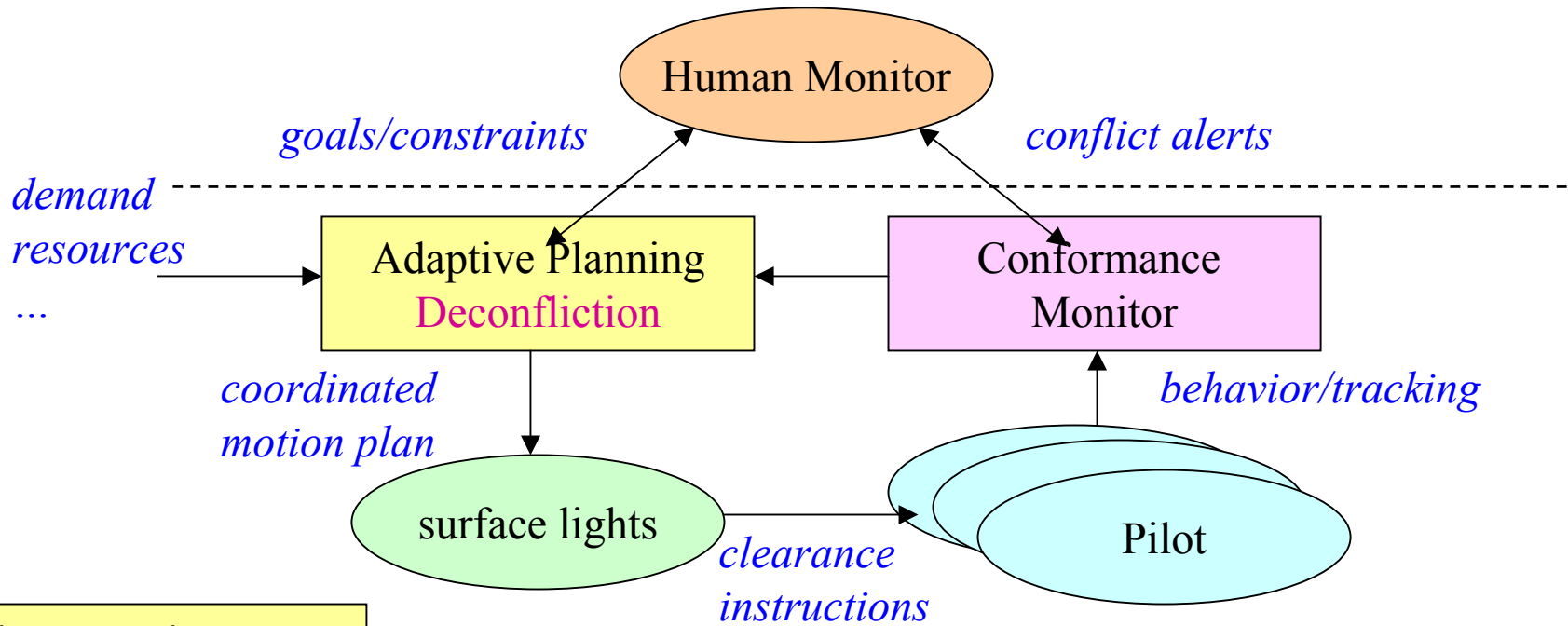
Human-Centered Design Philosophy



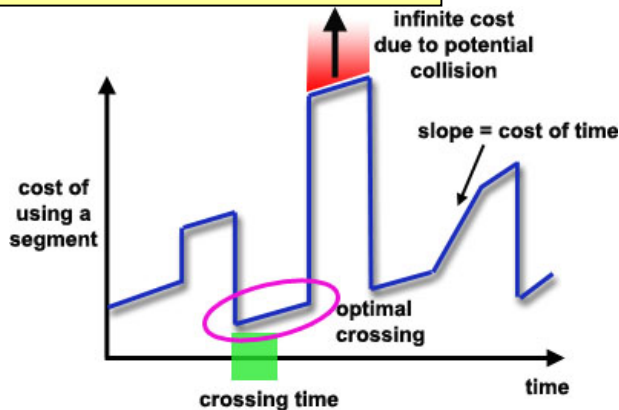
Roles and Responsibilities



Technical Aspects

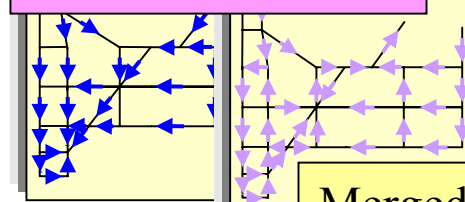


Time-Varying Costs

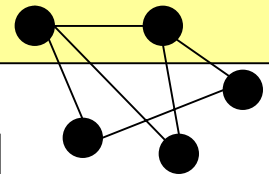


Explicitly Address Uncertainty

$$\min_{x \in X} E[H(x, \xi_x)]$$



Fast-Time Discrete Event Simulation

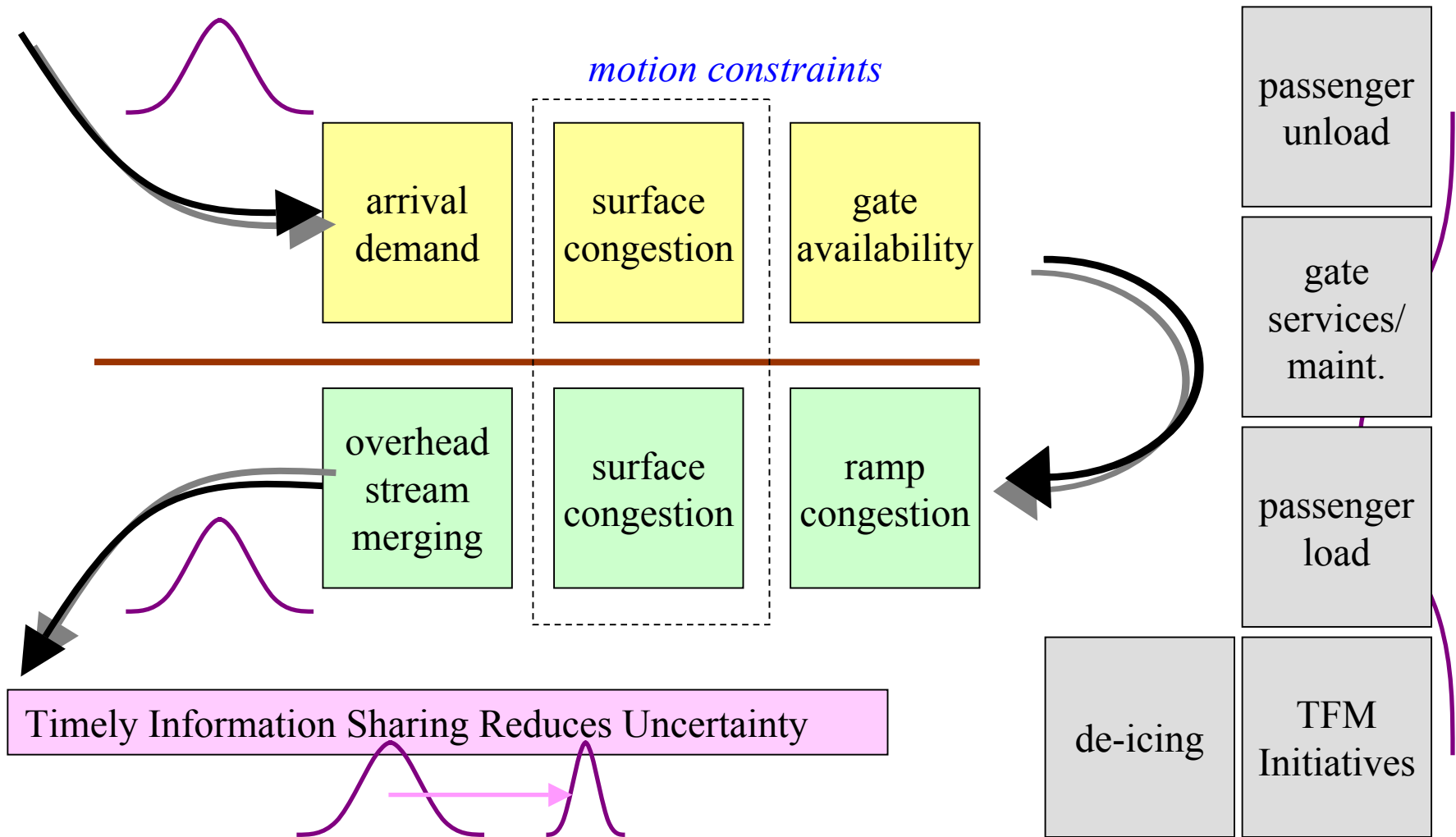


Merged Optimal Path Maps

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Constraints on Solution



Example Operational Concepts

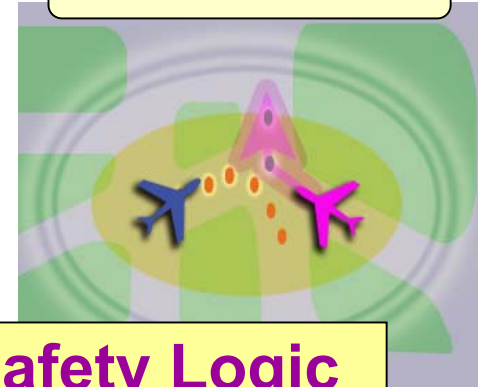
Normal Operation



Blunder Detected

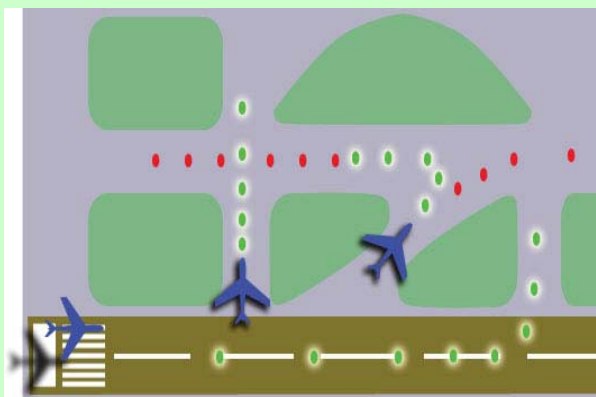


Conflict Resolved

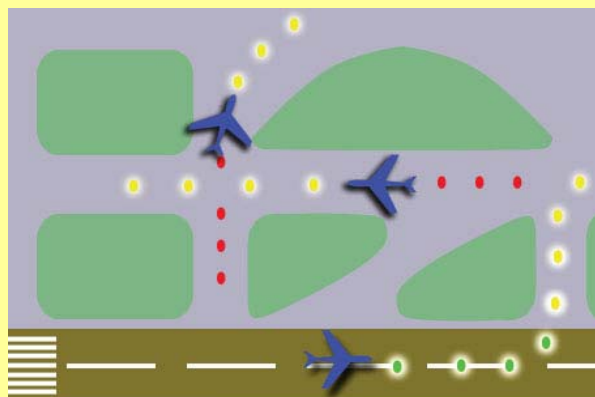


Separate Safety Logic

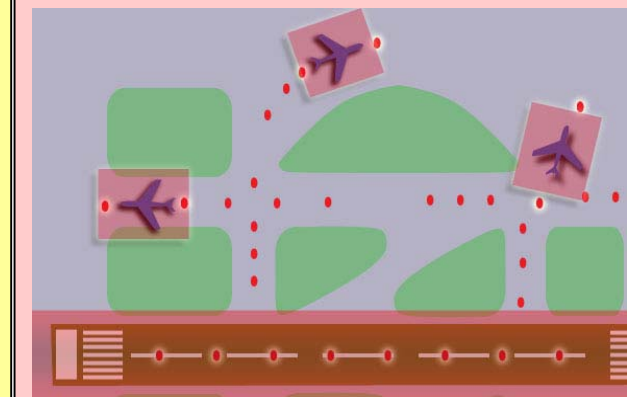
Normal operation



Failure Detected



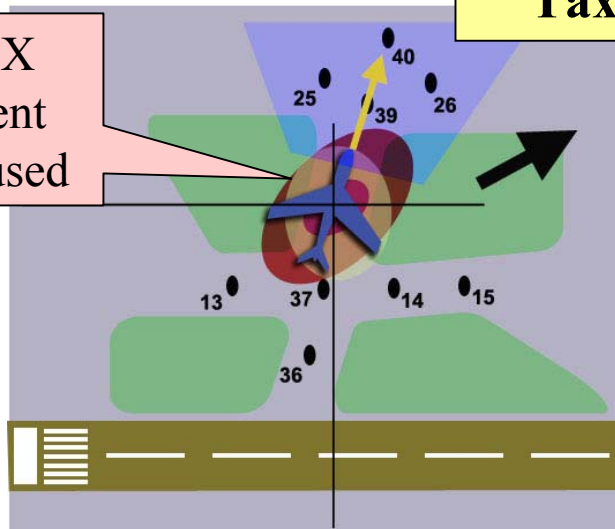
Stop Condition



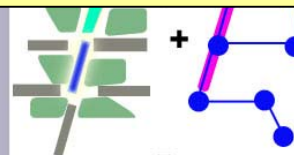
Fail Safe Operation

Enabling Technologies

GPS, ADS-B, ASDE-X
position, velocity, intent
and uncertainty data used



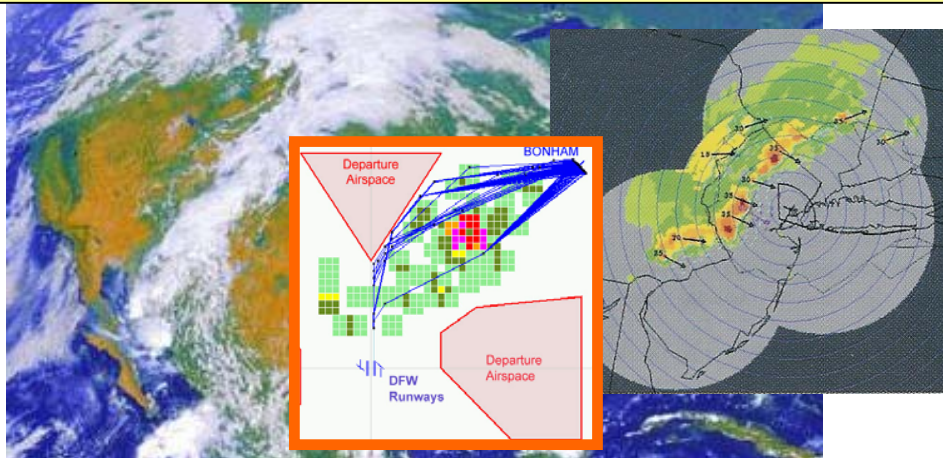
Taxiway Light Control System



Assignment of
updated colors to
all applicable
lights

25 ●
26 ●
39 ●
40 ●

Weather and User Response Prediction



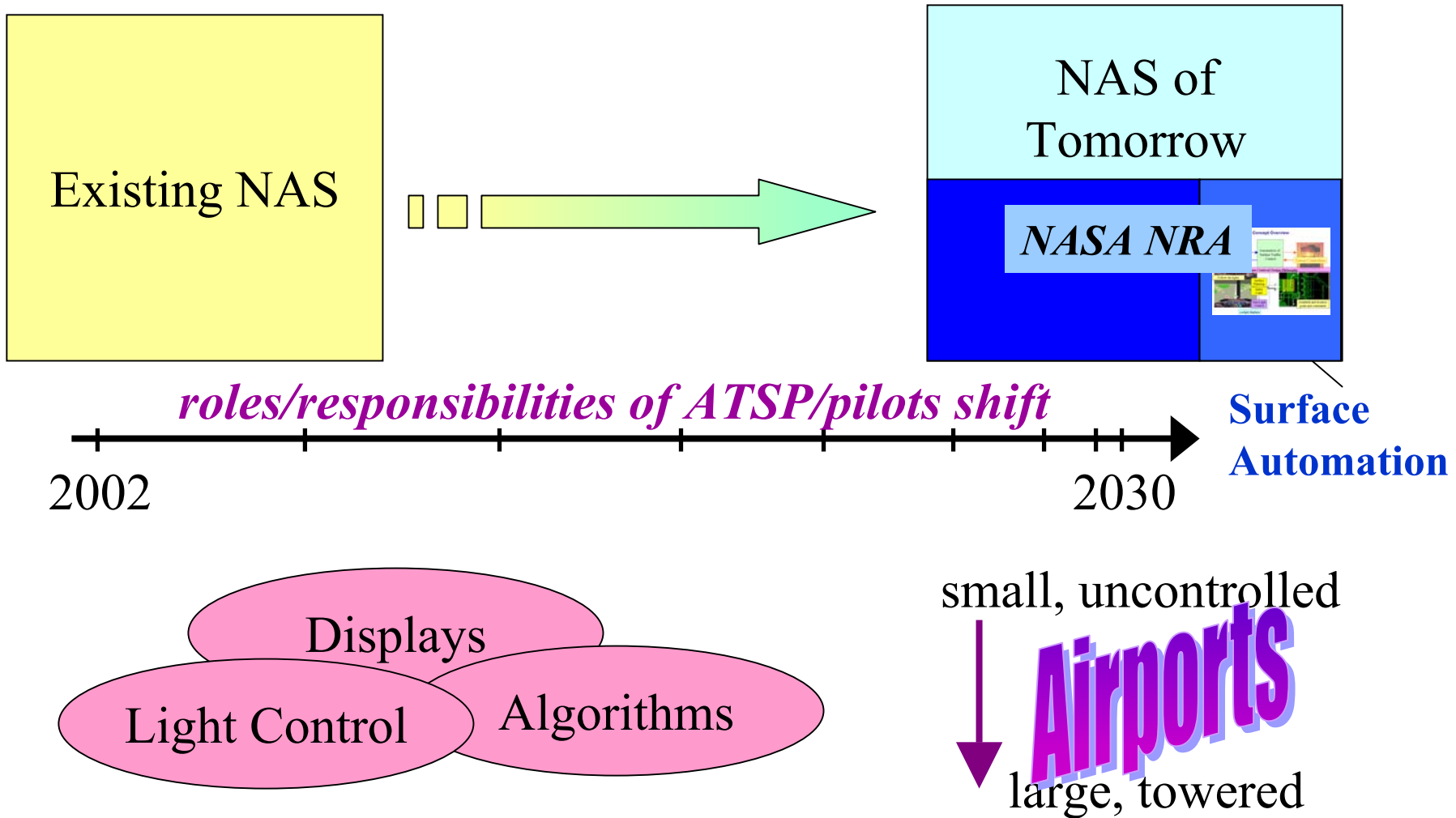
Microburst prediction
Storm Location & Motion
Terminal Winds

*Weather Sensing and
Prediction will mosaic the
NAS by 2010*

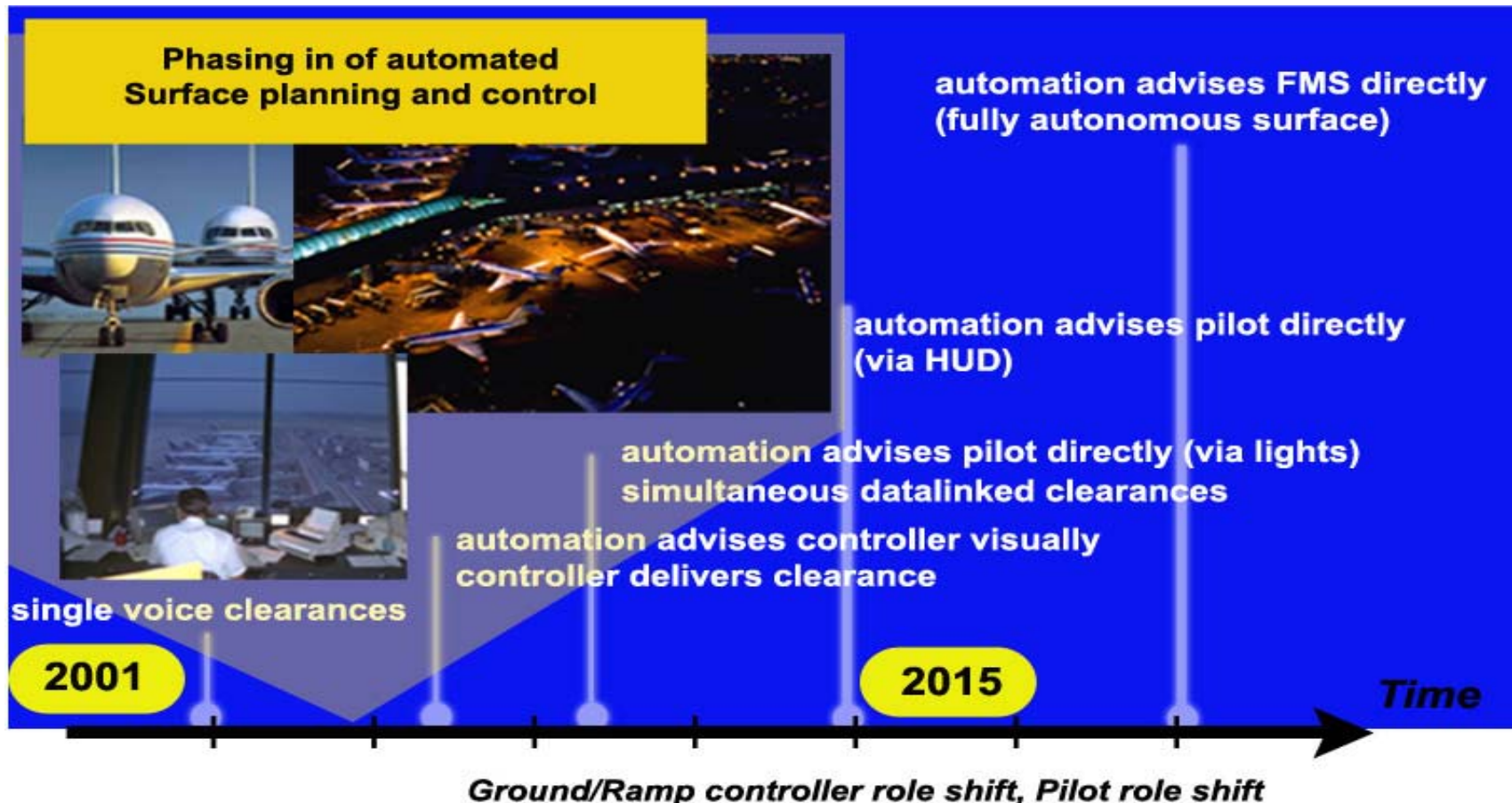
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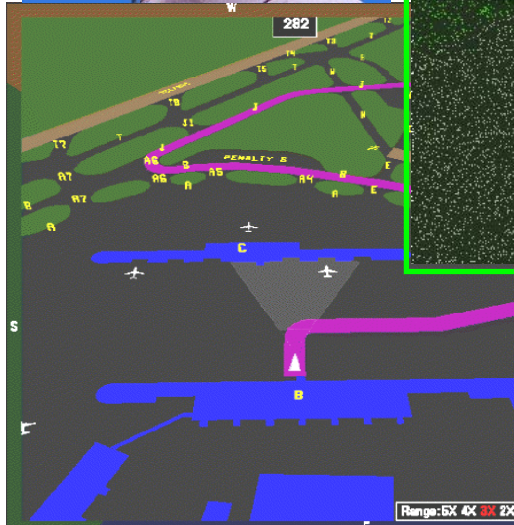
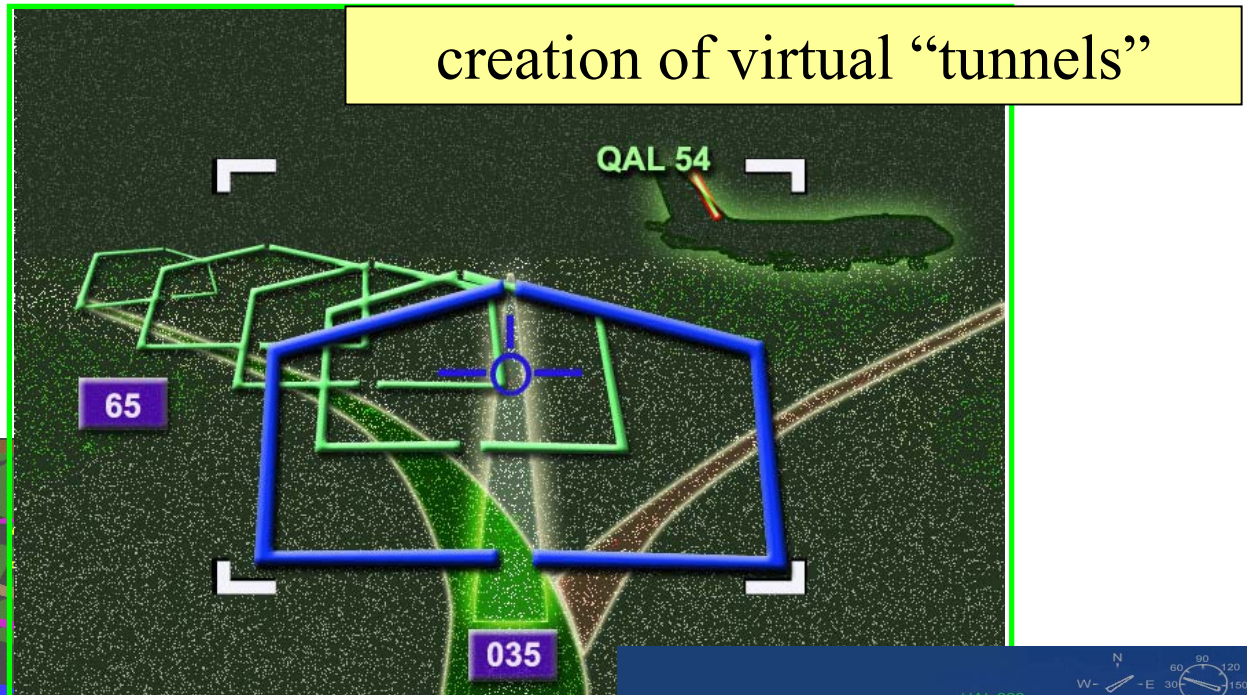
Roadmaps for New Technologies: Evolution



Roadmap for Surface Automation: Evolution



Use of Advances in Display Technology



Metrics of Goodness

Metric	Category	Description
Capacity	Airport Arrival Rate	Maximum number of arrivals (typically per hour) as measured by wheels “on” time upon landing
	Airport Departure Rate	Maximum number of departures per hour as measured by wheels “off” time
	End-to-End Throughput	Maximum number of arrival-to-departure events per hour (including gate turn time)
Predictability	Airport Time of Arrival (Departure) Prediction	Error in wheels on time (off time) as a function of prediction horizon time
Efficiency	Direct Operating Cost (DOC)	A metric determined by a combination of time and fuel
	Taxi-in time	Measured from touchdown to brakes applied at gate
	Taxi-out time	Measured from brake release to either wheels “off” time or radar target recognition (ACARS message)
	Average Queuing Time	Average amount of time spent in queues from pushback to start of departure roll

Metrics of Goodness

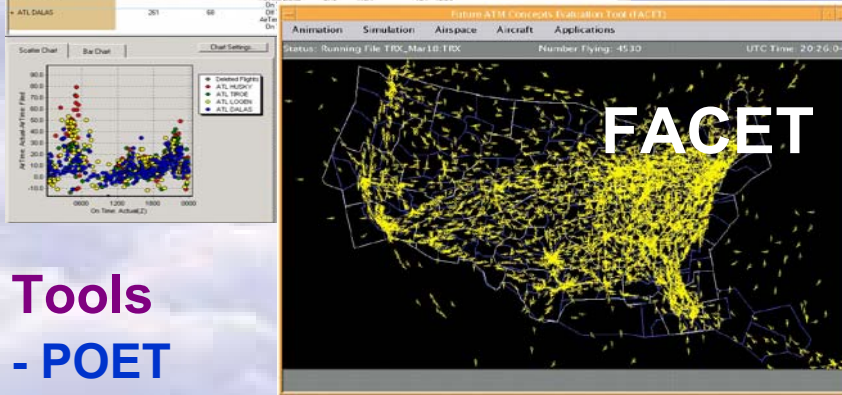
Metric	Category	Description
Environment	Noise	Average annual noise exposure (DNL)
	Pollution	Annual emissions of fuel-burn products
Safety	Conflict Alerts	Trajectory deviations due to Conflict Detection
	Runway Incursions	Incidents on the airport surface due to controller error or lack of pilot situational awareness
	Blunder recognition time	The time required for the controller to become aware of pilot errors in following clearances
Flexibility	User Preference	Accommodation of user preferences measured in terms of surface trajectory interruptions due to aircraft conflicts
	Slot Swapping	Total number of slots exchanged in surface path plans
	Block Swapping	Exchange occurring across windows or blocks of time (0-15min, 15-30min, etc.)
Equity	Delay Deviation	Measure of Delay Deviation amongst Users and User Categories

Metrics of Goodness – Cost/Benefits

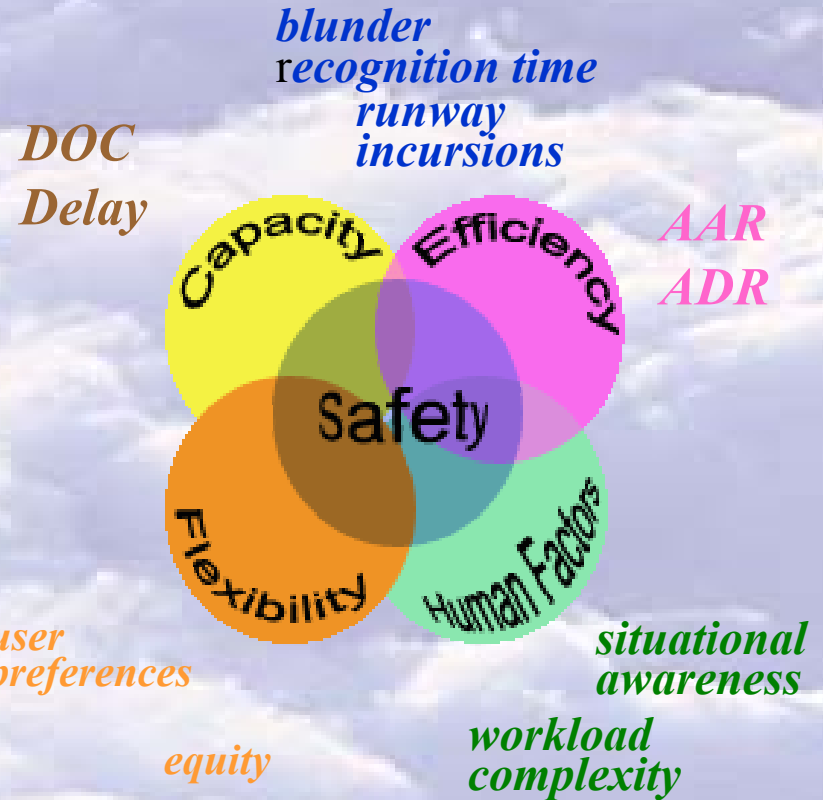
POET

Search Results - Table

Report: Arrival (Actual)	Planned For: Actual	Planned	Planned Delayed	Performance Metrics	Flight	Actual	Delayed
ATL HUSKY	210	81		On Time (%)	88.8	100.0	11.2
				Air Time (min)	85.8	80.0	5.8
				On Time (%)	100.0	100.0	0.0
ATL TRODE	305	38		On Time (%)	100.0	100.0	0.0
				Air Time (min)	88.0	79.0	9.0
				On Time (%)	100.0	100.0	0.0
ATL LODEN	305	89		On Time (%)	100.0	100.0	0.0
				Air Time (min)	86.0	84.0	2.0
				On Time (%)	100.0	100.0	0.0
ATL DALAS	281	68		On Time (%)	100.0	100.0	0.0
				Air Time (min)	87.0	83.0	4.0
				On Time (%)	100.0	100.0	0.0



- **Tools**
 - POET
 - FACET
 - Simulation-Based
 - Cognitive Walkthroughs
- **Analysis**
 - Historical, 2000, 2010, 2015, 2020
 - Scenario-Based
 - Iterative Improvement on Capacity Improving Concepts



Summary and Motivation

- **Surface Automation is a Logical First Step to ATC Automation**
- **A Shift in Roles and Responsibilities of ATSP/FD is needed**
- **Our Concept requires no new equipment in the cockpit**
- **A revolutionary solution with an evolutionary implementation**
- **The Demonstrations will follow**